A Blue Mussel, *(Mytilus edulis* Linnaeus*)*, Culture Pilot Project in South Coastal British Columbia

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ABSTRACT

Heritage, G. D. 1983. A blue mussel, Mytilus edulis Linnaeus, culture pilot project in south coastal British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1174: vii + 27 p.

An off-bottom method of growing mussels using mesh stocking material is described. The procedure employs the relay of intertidal mussels and collection of natural sets of mussels which are suspended from rafts and longlines. Growth is rapid, settlement intense but losses from sloughing, unexplained mortalities and predation by diving ducks are high.

Key words: mussels, mesh stocking, off-bottom, growth, settlement, mortalities.

RESUME

Heritage, G. D. 1983. A blue mussel, Mytilus edulis Linnaeus, culture pilot project in south coastal British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1174: vii + 27 p.

Le présent rapport porte sur une méthode de culture suspendue des moules à l'aide d'un matériau maillé. Ce procédé comporte la pêche et le transport de moules intertidales et la récolte d'aggrégats naturels de moules suspendues soit à des radeaux ou à des filins. La croissance rapide et le taux élevé de fixation sont contrebalancés par des pertes suite au détachment, à la mortalité inexpliquée et à la forte prédation par les canards plongeurs.

Mots-clés: moules, matériau maillé, culture suspendue, croissance, fixation, mortalité

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INTRODUCTION

An investigation of the feasibility of cultivating blue, or bay, mussels, Mytilus edulis, was carried out by the Pacific Biological Station beginning in 1978. The purpose was to grow mussels from seed to market size (50 mm), in south coastal British Columbia.

Mussel culture may be defined as placement of seed at locations where optimum conditions will assure rapid growth and protection from predators and extreme wave and tidal action.

Surveys of intertidal mussel beds were carried out, seed was relayed to each culture site and suspended in mesh stockings. Settlement of natural seed was monitored by examination of suspended ropes.

In general, the study showed that wild mussels relayed in the spring, grew to market size in two summers of suspension and natural seed collected in the spring grew to market size in 12-14 months. Spatfall of commercial intensity occurred at all sites in each of the 2 years. Mortalities during the summer were severe and predation by sea ducks in the winter resulted in heavy losses.

This report describes the study sites, procurement of seed, method of culture, growth, settlement, and mortalities.

STUDY SITES

Nine culture sites were selected in the Strait of Georgia, Sooke, Barkley Sound, and the Seymour Narrows-Yuculta Rapids area (Fig. 1). These locations were selected for proximity to possible markets, favorable conditions for growth of bivalves, and interest in diversification within the oyster industry in this region. Other criteria for choosing the study sites included availability of surveillance, exposure, water exchange, accessibility, salinity, temperature, and depth.

Freke Anchorage, at the east end of Malaspina Inlet, was chosen for its protection, and close proximity to an oyster lease. Rate of water exchange here is probably limited.

Elephant Point was known to have consistent heavy mussel sets, protected waters, good water exchange, and surveillance.

Oyster operations in the Baynes Sound area produce an estimated 60% of the total British Columbia oyster production annually (K. Albrecht, Marine Resources Branch, 2569 Kenworth Road, Nanaimo, B.C., personal communication). For this reason and because of available surveillance and good water exchange a site one nautical mile south of Union Bay was chosen.

Departure Bay was selected as a standard because of the previous work there (Quayle 1978). There is good water exchange and protection behind Brandon Island.

North Cove, the site of an oyster farm, is protected from south east winds and has an adequate water exchange.

Long Harbour, a protected bay, with limited water exchange was the most southerly location within the Strait of Georgia. A small oyster farm is located there.

Anderson Cove, with an oyster farm at the time of this study, was believed to be influenced by oceanic water and is well protected from wind. Water exchange here appeared to be limited.

Poett Nook, in Barkley Sound, was chosen because of its excellent protection, influence of oceanic water, and the availability of seed. Barkley Sound is a good oyster growing and clam producing area.

Waiatt Bay, in the Seymour Narrows-Yuculta Rapids area, was selected because it was believed the extreme tidal exchange and turbulence would provide nutrient-rich water, although reduced water temperature.

METHODS

1. SEED PROCUREMENT

Mussel growers throughout the world either catch seed on various collectors or gather wild seed from the intertidal zone (Korringa 1976). To assess the extent of wild mussel seed sources, surveys of intertidal areas and of net pens at two fish farms were carried out in the fall of 1978.

Areas surveyed in 1978 included Desolation Sound, Homfray Channel, Pryce Channel, Waddington Channel, the south side of Cortes Island, and the Copeland Islands. Beds suitable for gathering quantities of seed were difficult to find. This necessitated expansion of surveys, in 1979, to include a large part of the Strait of Georgia, Barkley Sound, and Sooke Basin.

In the spring of 1979 seed was gathered from intertidal beds at Fatty Basin, Brant Reef, East Redonda Island, net pens at Alberni Marine Farms in San Mateo Bay, net pen floatation in Departure Bay, and a boat bottom in Newcastle Channel (Fig. 2).

Seed used in 1980 was gathered from raft floatation at each culture site and from an oyster raft at Clam Bay, Kuper Island (Fig. 2).

Harvesting was carried out by either shovelling clusters off smooth rocks with a flat-nosed spade or scraping them from rock faces with a garden hoe. The later method required the use of a small square-frame dip net to catch the mussels as they fell from the rocks. Those collected from the net pens were scraped from the netting using a small plexiglass scraper or hand picked by divers.

2. CULTURE

The many methods of culturing mussels used throughout the world have varying degrees of success. Bottom culture in the Netherlands, raft culture in Spain, India, the Phillipines, and North America, culture on posts in Italy and the Phillipines and longline culture in Sweden, New Zealand, and North America are the major methods (Clime et al. 1979, Jenkins 1979, Korringa 1976, Lutz 1980, MacLeod 1975, Yap et al. 1979).

In British Columbia, intertidal, or bottom, culture has associated risks that include predation by starfish, crabs, urchins, fish and birds and freezing during periods of cold weather. Suspended culture reduces predation by bottom dwellers and eliminates freezing but floatation materials are costly. A further advantage is the rapid growth resulting from the continuous availability of food.

This type of culture was believed to be most suitable for British Columbia because of predators on the intertidal and subtidal bottom. The Spanish method of growing mussels on ropes is unacceptable because of excessive sloughing and the need for constant thinning. Grow-out in Netlon stockings was believed to be the best alternate method (Quayle 1978).

Netlon, available from RDB, 22060 Vigano, Brianza (como), is a synthetic stocking with fused knots and is available in a number of different mesh sizes. The use of proper mesh size is critical. If the mussels are unable to migrate through the mesh, after placement in the sock, mortalities and slow growth will eventually result from overcrowding.

Stocking material was cut to length (2 m) and knotted at one end. The open end was pulled over a 1 m length of 7.6 cm diameter thin walled pipe until the knotted end was tight against the end of the pipe. Seed clusters were inserted in the pipe until it was full; then the weight of the mussels pulled the mesh off the pipe to allow refilling. This process was continued until the sock was full, the open end was knotted and the stocking suspended by a 6.4 mm diameter polypropylene rope.

Clusters of seed with shell lengths measuring to 20 mm were placed in 25G 123 (4.0 cm stretched mesh), 20-40 mm in 14E 121 (7.0 cm stretched mesh), and 14E 123 (7.2 cm stretched mesh); 40 mm and larger seed were placed in 12E 132 (11.0 cm stretched mesh) Netlon stockings.

Two types of floatation were used in this study: wooden rafts with styrofoam floatation at all protected locations and both single and double longlines at exposed locations (Fig. 3). Rafts, measuring 2.7 m by 3.7 m, were

constructed of rough cedar lumber and styrofoam logs. The single longline system was made up of one length of 19 mm yellow polypropylene rope attached to 2-318 kg railway wheel anchors and buoyed with 10-48.5 cm diameter Scotchman fishing floats. A 136 kg concrete counter weight was attached to the main line at one end between the anchor and float to keep the longline tight when the tide ebbed. The double longline system used 2 lengths of 19 mm black polypropylene rope attached at each end of 5 polyethylene barrels and bridled at each end. The bridles were shackled to 19 mm polypropylene anchor lines attached to 5 m of 12.5 mm galvanized chain shackled to 39 kg Danforth anchors. A counter weight weighing approximately 91 kg was attached, to the anchor line at one end, to keep the system tight during low tides. In both cases where counter weights were employed, they were not allowed to make contact with the bottom.

3. SAMPLING

Seed was gathered and transported to the laboratory in galvanized tubs. A sample was taken, individuals separated, fouling organisms removed, and each individual was measured and weighed. Clusters of seed were then placed in stockings which were then weighed to the nearest kilogram before suspension. In some cases the newly socked mussels were stored in tanks until enough were accumulated to take to the culture sites for suspension.

Initially, monthly sampling was done at each location but it became irregular during the course of the study. During visits individual socks were weighed and samples taken for length and weight measurements. As socks were lifted for weighing it was common for some mussels to slough. These were caught and used for the samples. Fouling organisms, dead shell, pseudofeces and detritus were weighed occasionally. To reduce disturbances to mussels, socks weighed during one visit were not weighed on the next visit.

4. GROWTH

Cumulative percent frequencies of lengths were plotted on probability paper, the modes separated and mean lengths and standard error of each mode calculated (Cassie 1954). The mean lengths of modes were then plotted against time as a measure of growth. No further analysis of growth was attempted because of discrepancies in the plots, e.g., negative growth during some periods and rapid growth during periods of the year when slow growth was expected.

Negative growth is when, because of losses and the influx of natural seed, the mean length of randomly sampled mussels decreases with time. Where possible, growth of seed from one source was compared at different culture sites and growth of seed from different sources was compared at the same culture site. A comparison of the growth of the 1979 natural set was possible at 3 culture sites.

5. NATURAL SETTLEMENT

Growers may wish to catch their seed rather than gather it from the shore or floating structures, as described earlier. To obtain information on settlement, collectors were suspended from the rafts and longlines. The collectors used in 1979 were 19 mm diameter, polypropylene ropes roughened with a grinder to provide a greater surface area for attachment of the larvae. Two lengths, 3 m and 6 m, were suspended vertically at all but the Anderson Cove site where only 3 m ropes were hung. Some settling occurred close to the surface at most sites in 1979; in 1980 the collector ropes were suspended horizontally, near the surface.

During visits to the culture sites spat collectors were removed from the water and examined. The presence of small mussels and their location on the rope collectors was noted. Length-weight samples were removed from clusters that appeared ready to slough. The collectors were then returned to the water if a new collector was not suspended.

6. LOSSES OF MUSSELS

Mussel losses were estimated during visits to the sites and when possible, counts of moribund and dead individuals were carried out. Losses were categorized as sloughing, unexplained deaths and predation related. Sloughing occurred in spring and summer when rapid growth and weight gain caused mussels to drop from the socks. Socks would commonly be missing large sections of mussels and in many cases small seed would have migrated into the space remaining. Unexplained deaths were those loses in which individual mussels were found to be gaping or empty. Predation related loses were concluded to be those during the fall and winter months when entire socks were stripped by sea ducks.

RESULTS

1. GROWTH

1.1 Growth of Relayed Seed

Regardless of origin, relayed seed of similar mean lengths generally grew at the same rate at each culture site (Fig. 4).

At sites where seed of different mean lengths (from different sources) were suspended, growth of smaller, younger, individuals was more rapid than that of larger, older, individuals during the first growing season. The initially smaller mussels approximated the size of the larger ones in only a few months (Fig. 5).

At the sites utilized, average growth appeared similar (Fig. 6).

Most relayed mussels did not reach market size (50 mm); however, East Redonda Island seed grew to 50 mm at the sites where they were grown. They grew from 29 mm to 50 mm in 8 months at Freke Anchorage, in 9 months at Baynes Sound and in 11 months at Long Harbour. Table 1 summarizes the maximum lengths attained by the mussels relayed from the various sources to the culture sites and the time it took to reach these sizes.

1.2 Growth of 1979 Natural Set

Growth of the natural seed collected in 1979 could be followed at only 3 sites: Freke Anchorage, North Cove, and Anderson Cove (Fig. 7). Market size was attained by May 1980.

The exact dates of settlement are unknown but it is believed that the 50 mm mean length was reached in 12 to 14 months. Settlement has been noted as early as March by some observers (Quayle 1978, Heritage unpublished data).

1.3 Growth of 1980 Natural Set

Growth of seed collected in 1980 could not be accurately followed because of severe losses and final termination of the study. However, at Waiatt Bay, seed believed to have settled in August 1980 grew to a mean length of 54 mm by September 1981.

2. SETTLEMENT

Concentrations of spat were found near the surface on rafts, longlines, and collector ropes at most sites in 1979. Collectors at Departure Bay and Anderson Cove had settlement throughout their entire length. Seed was successfully collected in 1980 on horizontally hung ropes at all culture sites. Setting at most sites tended to follow the same general pattern. Settlement began in March and April, peaked in June, continued at low levels through the summer and peaked again between August and October. No settlement was observed during the winter months.

Table 2 shows the months when spatfall peaked at each culture site in 1979 and 1980. Where blanks are present there was no set and in cases where "no peak" is written there was extended low level settlement which resulted in a spatfall judged to be of commercial intensity. Commercial sets took place at all culture locations in 1979 and 1980; however timing of the main setting periods varied with location and year.

3. MORTALITIES

Throughout this study large numbers of mussels were lost at all sites and in most cases resulted in termination of growth studies because few animals remained. Losses followed a general pattern: sloughing in spring during rapid growth and weight gain, unexplained deaths starting in late summer and duck predation in the winter.

No record of sloughing could be kept because spaces left by clumps of mussels dropping from the socks would soon be filled by those needing more space for attachment and growth. Sloughing was common when socks were removed from the water for weighing and sampling. The mussels tended to attach more to one another than to the mesh which resulted in weak attachments to the substrate. Any wave action or lifting resulted in losses of part, or all, of the mussels on the socks.

Unexplained deaths occurred throughout the study period (Table 3).

Predation by black scoters, Melanitta nigra, surf scoters, M. perspicillata, white wing scoters, M. fusca, Barrow's goldeneyes, Bucephela islandica and common goldeneyes, B. clangula took place throughout the Strait of Georgia, Anderson Cove, and Poett Nook between September and March each winter. The birds seemed to prefer mussels to approximately 35 mm in length but in taking these small individuals would also knock off other larger ones. Predation by ducks was worst at Baynes Sound, Anderson Cove, Elephant Point and Freke Anchorage. Mussels growing at the other sites did not escape duck predation entirely but did not suffer losses like the above sites where entire socks were stripped.

Predation by pile perch, Rhacochilus vacca, observed on four occasions, appeared not to be a serious problem. However, these fish were seen feeding on small mussel seed at North Cove, Poett Nook, Long Harbour, and Departure Bay during the summer.

DISCUSSION

Throughout the study, difficulties were encountered in estimating growth rates. Mean lengths of populations decreased at times because losses were size related (large, old mussels died and sloughed off) when, in fact, most individuals within the populations were growing. Analysis of size frequency distributions (Cassie 1954) were believed to be the most accurate method of estimating growth with the available data. However, without actually tagging individuals, it must be noted that the growth rates indicated are population estimates only.

Prerequistes for most farming operations, including the culture of bivalves, consist of adequate and reliable seed sources, optimal growth conditions, high survival and development of products consumers will readily

accept. Mussel seed can be collected in commercial quantities throughout the Strait of Georgia and in Barkley Sound. Unless there is a drastic change in oceanographic conditions natural settlement can be expected to be an annual occurrence as has been the case in Hotham Sound and in Departure Bay for a number of years (Heritage and Quayle, unpublished data). Growth to market size in southern British Columbia waters has been found to compare to that in the Roads of La Spezia, Italy where mussels are harvested during the second summer of their life (Korringa 1976). Growth rates were not generally influenced by location of culture sites. However tidal flow was important for where circulation was slow, byssal attachments were weak and losses greater than in areas with flows of 2 or 3 knots.

Although seed procurement and growth rates were found to be acceptable for successful farming operations, futher research will be necessary to discover means of overcoming problems associated with survival. Testing of different collector/grow-out substrates could determine more suitable materials to reduce loses caused by sloughing. A reduction in sloughing would definitely do away with much handling required in thinning the mussel crop. Mussel farmers in eastern Canada have reduced losses successfully by using Vexar strips to collect and grow their product (Muise and MacLeod 1980). This method may be suitable for use in British Columbia with no adaptions necessary. Losses from predation by waterfowl continue to plague mussel farmers in North America and parts of Europe and at present no practical deterrent has been developed. This problem was suggested by Lutz, 1980, to be "perhaps the largest biological problem facing the North American mussel industry". Effort must also be channeled towards finding the cause of summer mortalities and possible treatments to reduce, or overcome, this enigma.

SUMMARY

1. Seed, in the 10-30 mm size range, collected from the intertidal zone in the spring did not grow to market size by October or November, as suggested by Quayle in 1978. Natural sets were capable of growing tc market size in 14 months provided they set early in the spring and remained suspended for the entire period.

2. The Italian method of culturing mussels using Netlon mesh stockings was unsuitable because of sloughing. Too much handling was necessary.

3. Collection of commercial quantities of seed at the culture sites was possible during each of the 2 study years.

4. Losses were exceptionally high in individuals approaching market size.

5. Predation by water fowl resulted in heavy losses.

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Table 1. Maximum lengths of mussels relayed and grown at eight sites in 1979. Brackets enclose time in months to maximum length after relay. Seed source and initial length of seed are in the horizontal column.

Culture site	Fatty Basin 10mm	Brant Reef 10mm	East Redonda Island 29mm	San Mateo Bay 23mm	Departure Bay 31mm	Newcastle Channel 20mm	Pipestem Inlet 20mm
Freke Anchorage			50mm(8)				
Elephant Point	37mm(5)					37mm(8)	41mm(8)
Baynes Sound		46mm(9)	50mm(9)				
Departure Bay	47mm(12)			45mm(10)			
North Cove					43mm(5)		
Long Harbour		45mm(10)	56mm(12)				
Anderson Cove	45mm(11)			47mm(12)		37mm(9)	43mm(10)
Poett Nook	40mm(11)			45mm(11)			

Table 2. Months of peak settlement of M. edulis at 9 locations in south coastal British Columbia. "No peaks" and ---- mean extended setting and blanks mean no setting.

Location	Months		Year
Freke Anchorage	April	Sept-Oct	1979
	June	Oct	1980
Elephant Point	May-June	-	1979
	June-July	Aug	1980
Baynes Sound	no peak	Oct	1979
	Mar-Apr	-	1980
Departure Bay	July	Oct	1979
	no peak	Aug	1980
North Cove	June	-	1979
	June-July	Aug-Sept	1980
Long Harbour	-	Aug	1979
	no peaks	no peaks	1980
Anderson Cove	Apr-May	Sept-Oct	1979
	May ----	Aug	1980
Poett Nook	May	-	1979
	May-Aug	-	1980
Waiatt Bay	-	Aug	1980

Table 3. Percent mortality of mussels sampled at 8 culture sites, June 1979-Apr 1980.

Location & seed source	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				1979			
Freke Anch.							
(East Redonda Is)	-	-	-	15	-	3	-
(Local, 1979)							
Elephant Point							
(Fatty Basin)	-	0	—	9	-	-	-
(Newcastle Ch)	-	0	-	11	-	-	-
(Pipestem Inlet)	-	0	-	15	-	-	-
(Local, 1979)	-	-	-	-	-	-	-
Baynes Sound							
(Brant Reef)	-	0	-	13	-	8	7
(East Redonda Is)	-	0	-	10	-	17	9
(Freke Anch 1979)	-	-	-	-	-	-	-
Departure Bay							
(San Mateo Bay)	-	0	-	0	25	15	-
(Fatty Basin)	-	0	-	0	-	13	-
(Dodd Narrows)	-	0	-	-	-	26	-
North Cove							
(Departure Bay)	0	-	*25	*>50	-	45	-
(Local, 1979)	-	-	-	-	-	3	-
Long Harbour							
(Brant Reef)	-	0	-	29	24	-	7
(East Redonda Is)	-	0	-	25	32	-	31
(Local, 1979)	-	-	-	-	-	-	0
Anderson Cove							
(Fatty Basin)	-	-	0	-	13	-	26
(San Mateo)	-	0	0	-	15	-	-
(Newcastle Ch)	-	-	0	-	23	-	24
(Pipestem Inlet)	-	-	0	-	20	-	13
(Local, 1979)	-	-	-	-	0	-	14
Poett Nook							
(Fatty Basin)	-	-	-	-	-	-	-
(San Mateo)	-	-	-	-	-	-	-
(Local, 1979)	-	-	-	-	-	-	-

*is a visual estimate.

Table 3 (cont'd)

Location & seed source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
						1980					
Freke Anch.											
(East Redonda Is)	-	-	-	-	-	-	-	-	-	-	-
(Local, 1979)	-	-	-	-	-	-	*50	-	43	-	-
Elephant Point											
(Fatty Basin)	-	-	-	-	-	-	-	-	-	-	-
(Newcastle Ch)	-	-	-	-	-	-	-	-	-	-	-
(Pipestem Inlet)	-	-	-	-	-	-	-	-	-	-	-
(Local, 1979)	2	-	0	-	-	*100	-	-	-	-	-
Baynes Sound											
(Brant Reef)	-	-	-	-	-	-	-	-	-	-	-
(East Redonda Is)	-	-	-	-	-	-	-	-	-	-	-
(Freke Anch 1979)	-	9	-	-	-	-	*100	-	-	-	-
Departure Bay											
(San Mateo Bay)	-	-	13	13	-	-	-	-	-	-	-
(Fatty Basin)	-	9	12	13	-	-	-	-	-	-	-
(Dodd Narrows)	-	-	9	-	-	-	-	-	-	-	-
North Cove											
(Departure Bay)	-	-	-	-	-	-	-	-	-	-	-
(Local, 1979)	-	1	5	-	0	-	12	-	-	-	-
Long Harbour											
(Brant Reef)	-	*>9	-	-	-	-	-	-	-	-	-
(East Redonda Is)	-	*>18	-	31	-	-	-	-	-	-	-
(Local, 1979)	-	0	-	2	0	-	7	15	-	-	-
Anderson Cove											
(Fatty Basin)	-	-	-	9	-	-	-	-	-	-	-
(San Mateo)	-	0	-	-	-	-	-	-	-	-	-
(Newcastle Ch)	-	-	-	14	-	-	-	-	-	-	-
(Pipestem Inlet)	-	-	11	18	-	-	-	-	-	-	-
(Local, 1979)	-	0	-	1	-	-	-	1	-	-	-
Poett Nook											
(Fatty Basin)	-	-	-	3	-	-	-	-	-	-	41
(San Mateo)	-	-	9	1	-	-	-	-	-	-	32
(Local, 1979)	-	-	1	0	-	-	-	1	-	-	21

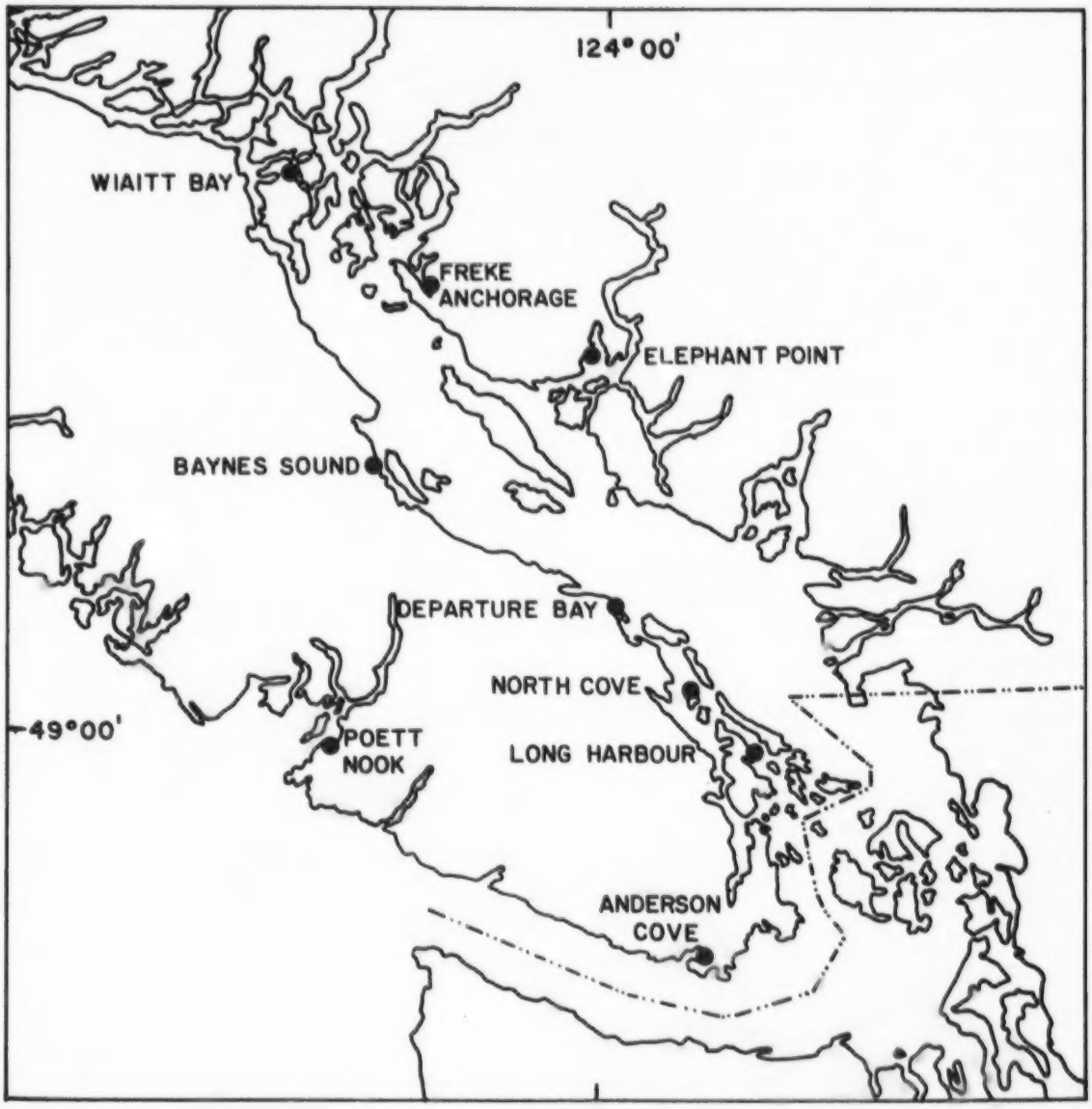


Fig. 1. Map of south coast of British Columbia showing raft and longline sites for mussel culture study.

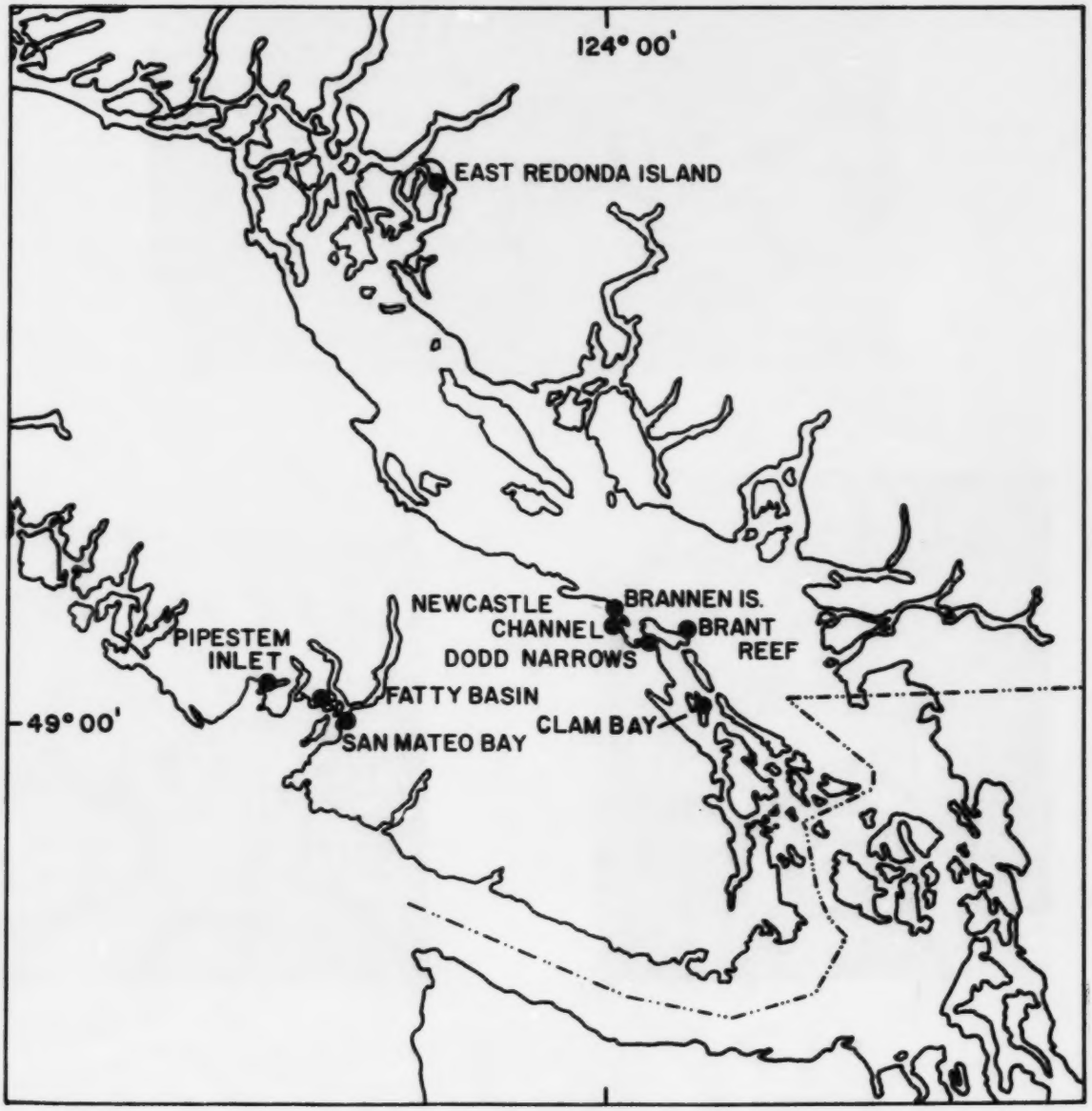
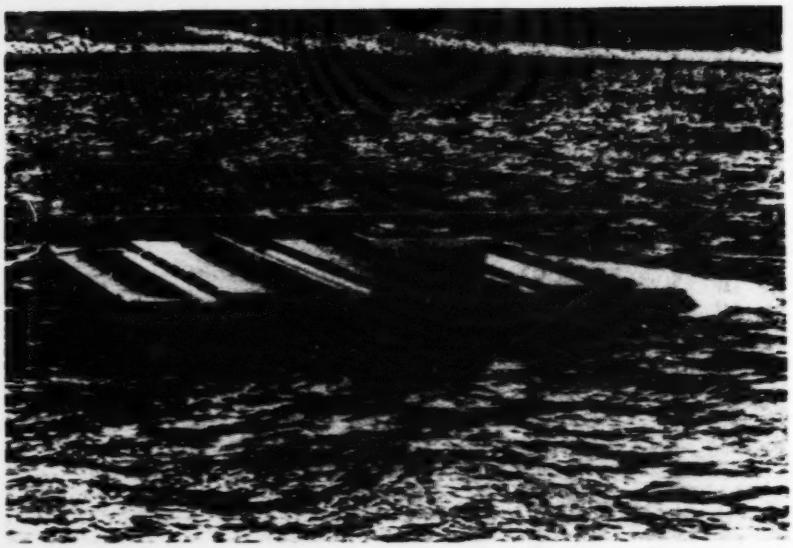


Fig. 2. Map of south coast of British Columbia showing sites where intertidal seed was gathered.



(a)

(b)

(c)

Fig. 3. (a) Raft constructed using rough cedar and styrofoam logs, 2.7 x 3.7 m.
(b) Single longline used at Baynes Sound.
(c) Double longline using plastic barrels as floatation, Waiatt Bay.

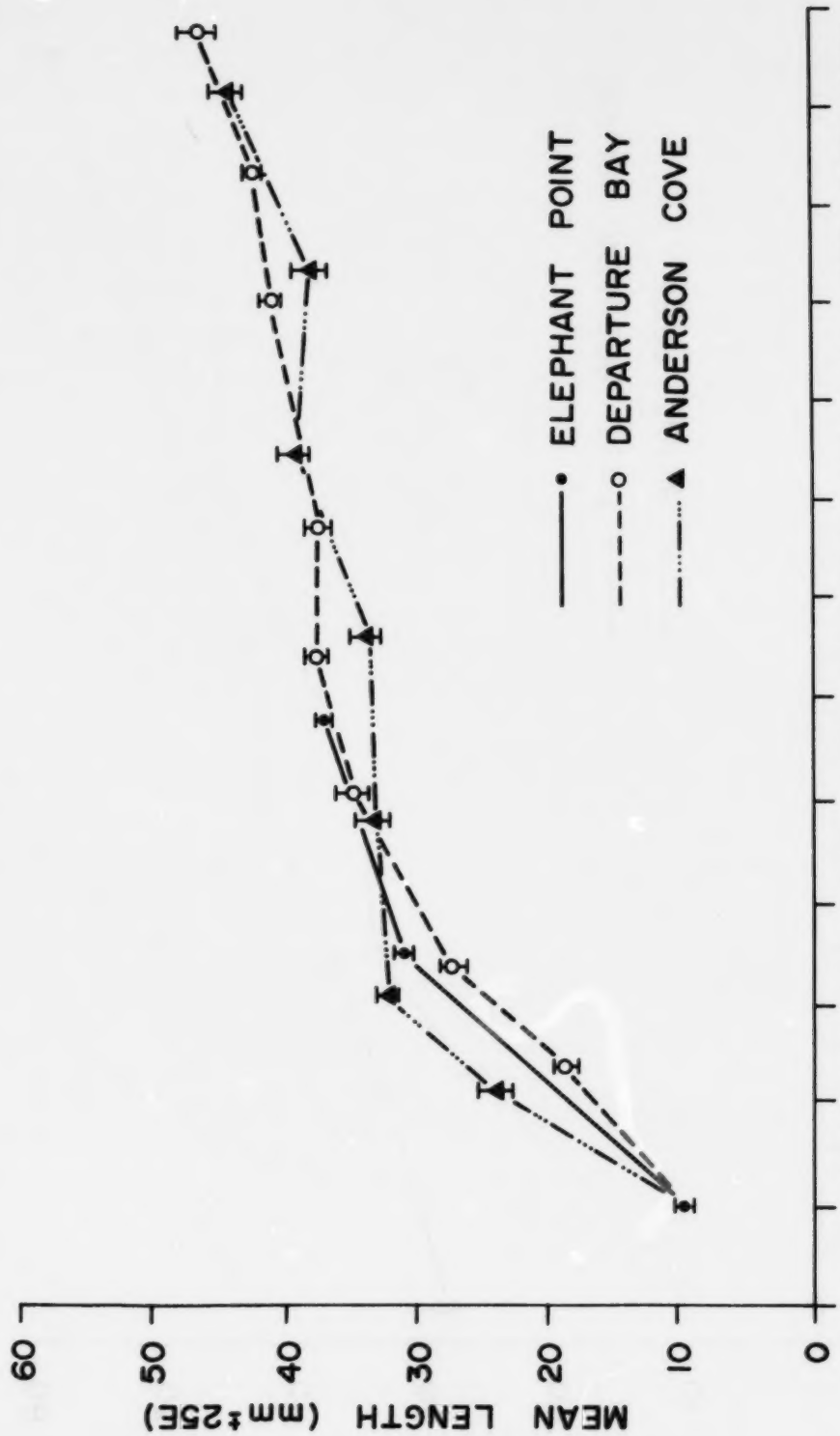


Fig. 4. Growth of M. edulis relayed from Fatty Basin and suspended at Elephant Point, Departure Bay, and Anders on Cove.

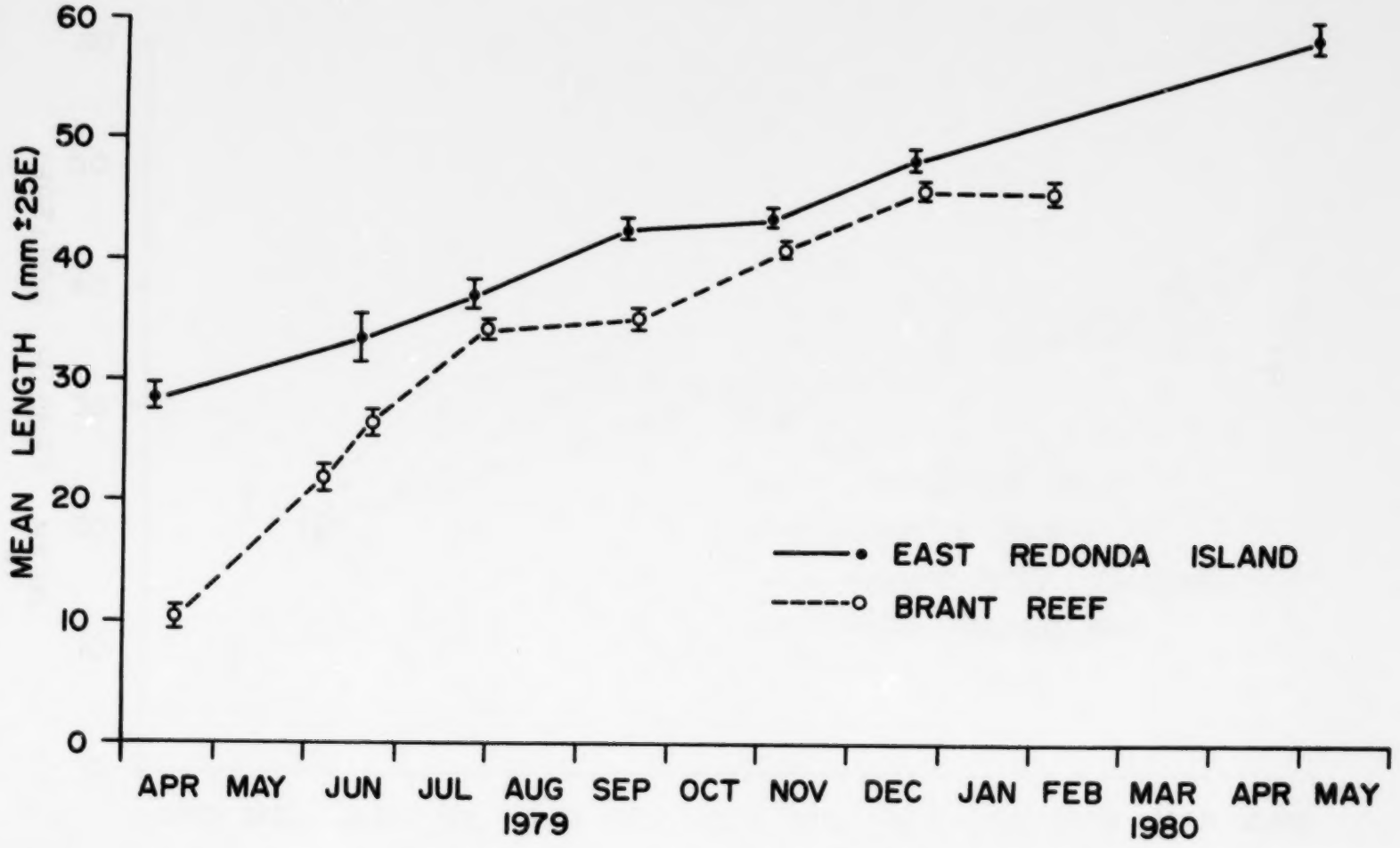


Fig. 5. Growth of M. edulis relayed from East Redonda Island and Brant Reef and suspended at Baynes Sound.

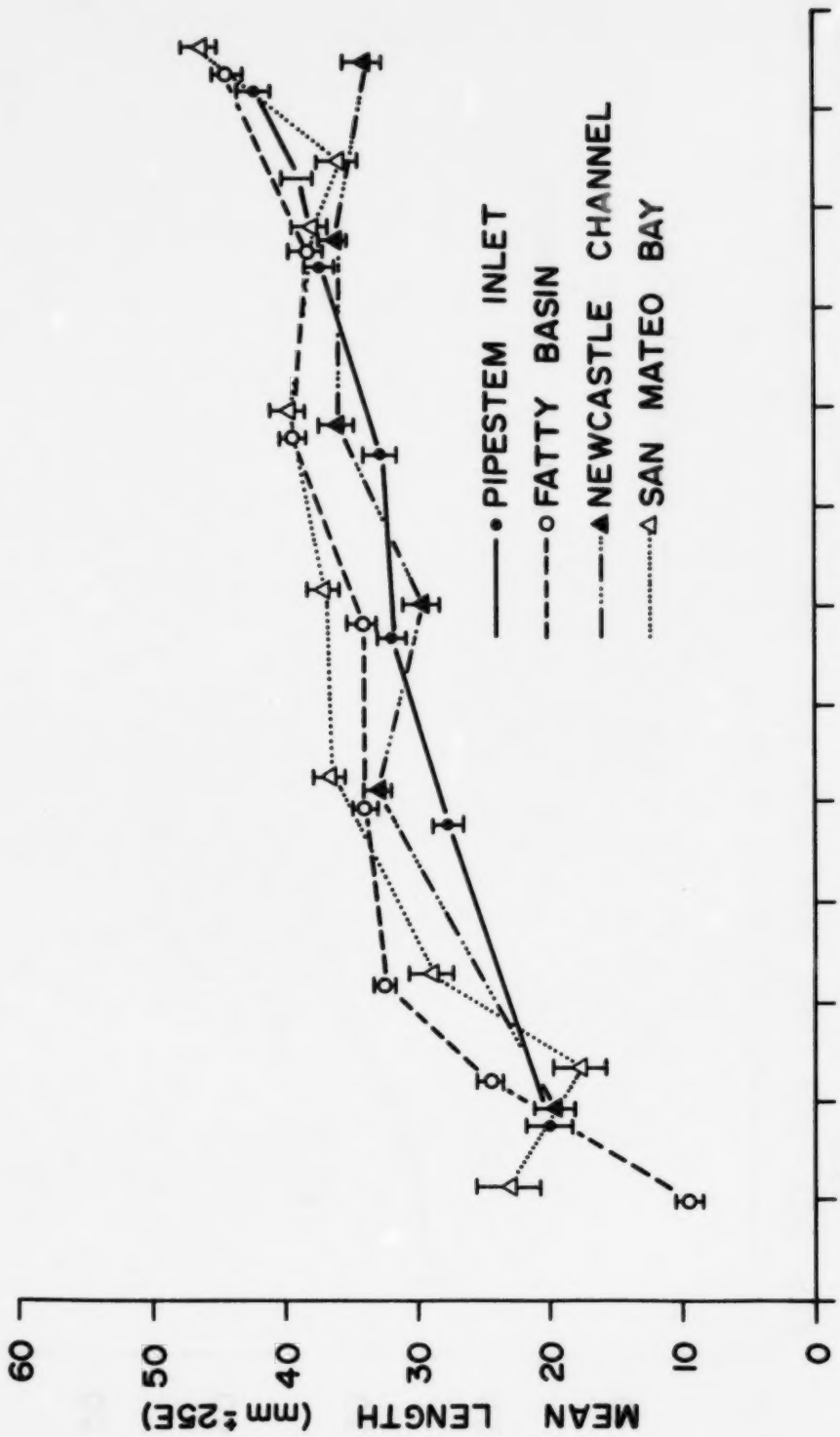


Fig. 6. Growth of M. edulis relayed from Pipestream Inlet, Fatty Basin, Newcastle Channel, and San Mateo Bay and suspended at Anderson Cove.

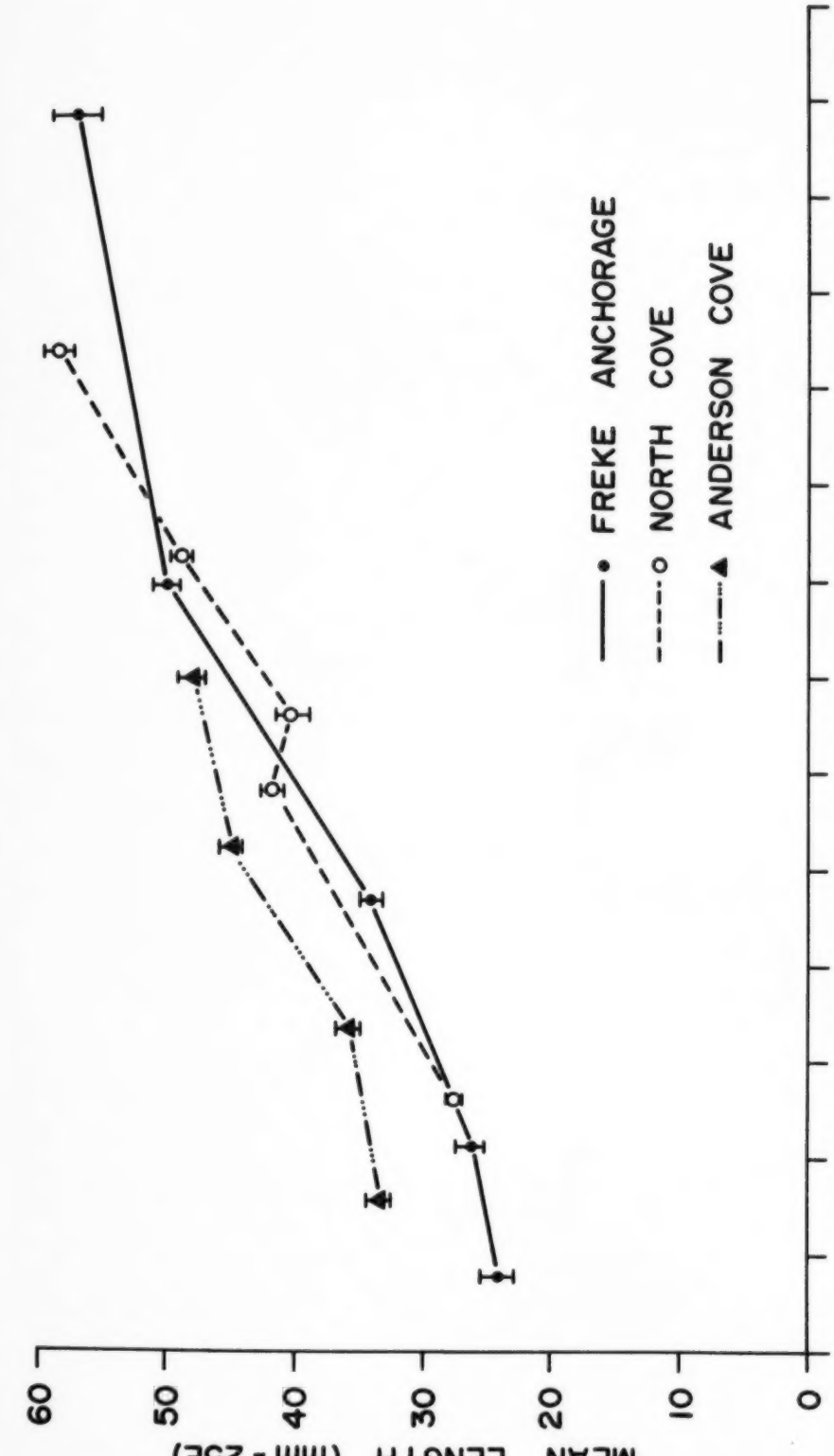


Fig. 7. Growth of 1979 natural set of M. edulis at Freke Anchorage, North Cove, and Anderson Cove.